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(54) FLUID OPERATED PUMP FOR USE IN A WELLBORE

(57) A fluid operated pump for use in a wellbore utilizes a removable valve assembly 300 within a longitudinal bore 225 in a housing 200 of the pump. A first fluid path 250 in the housing 200 opening into the bore 225 is provided for supply of pressurized fluid from the bore to an area of the pump below the housing, and a second fluid path 235 in the housing 200 opening into the bore 225 is provided for an exhaust fluid from an area below the housing to the exterior of the housing. In use the valve assembly is lowered to a location in the wellbore proximate the bore 225 in the housing 200, and, after being aligned with and axially inserted into the bore 225 such that ports in an outer valve surface communicate with the first and second fluid paths 250, is sealingly retained in the bore 225 during pumping of fluid by the pump. The valve assembly 300 is then operated within the bore 225 by motive hydraulic fluid supplied to the bore 225 by hydraulic fluid control conduits 345, 350.

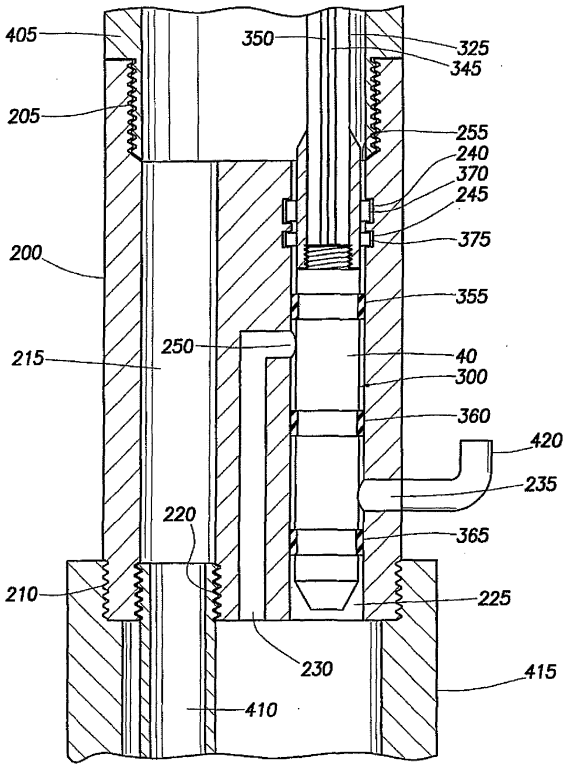

FIG.4

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Description

[0001] The present invention relates to a fluid operated pump for use in a wellbore.

[0002] Oil and gas wells include a wellbore formed in the earth to access hydrocarbon-bearing formations. Typically, a borehole is initially formed and thereafter the borehole is lined with steel pipe, or casing in order to prevent cave in and facilitate the isolation of portions of the wellbore. To complete the well, at least one area of the wellbore casing is perforated to form a fluid path for the hydrocarbons to enter the wellbore. In some instances, natural formation pressure is adequate to bring production fluid to the surface for collection. More commonly however, some form of artificial lift is necessary to retrieve the fluid.

[0003] Artificial lift methods are numerous and include various pumping arrangements. One common pump is a gas operated pump, as shown in Figure 1. Figure 1 is a section view of a wellbore with a gas operated pump disposed therein. The pump 30 is located adjacent perforations in the wellbore 10. The pump operates with pressured gas injected from a high pressure gas vessel 24 into a gas supply line 80 to a valve assembly 40 disposed in a body of the pump 30. The valve assembly 40 consists of an injection control valve 70 for controlling the input of gas into an accumulation chamber 34 and a vent control valve 90 for controlling the venting of valve assemblies for a gas operated pump have an internal bypass passageway for injecting gas into the chamber. The internal bypass passageway must be a large enough diameter to facilitate a correct amount of gas flow into the chamber. These internal structures necessarily make the valve large and bulky. A bulky valve assembly is difficult to insert in a downhole pump because of space limitations in a wellbore and in a pump housing.

[0004] US Patent 2336683 Hatfield discloses a method and apparatus for pumping well fluid from a well utilising gas as the lifting medium. In one embodiment a valve assembly is insertable on the end of a macaroni through well tubing into a seating member, and the valve assembly is then actuable by a weight bar that is lowered through the macaroni on the end of a wireline. However, there is no suggestion that the valve assembly can be subsequently withdrawn from the well to enable it to be replaced.

[0005] It is an object of the invention to provide a fluid operated pump having an improved valve assembly and operation.

[0006] According to the present invention, there is provided a fluid operated pump for use in a wellbore, the pump comprising a housing with at least one longitudinal bore therethrough; a first fluid path formed in the housing and opening into the bore for communicating a pressurized fluid from the bore to an area below the housing; a second fluid path formed in the housing and opening into the bore for communicating an exhaust fluid from an area below the housing to the exterior of the housing; and a removable valve assembly axially insertable into the bore of the housing and having ports that are constructed and arranged in an outer valve surface to communicate with the first and second fluid paths when the valve assembly is inserted into the bore and to selectively direct the pressurized fluid and the exhaust fluid; characterised in that fluid actuating means is providing for communicating motive fluid to the bore in order to operate the valve assembly within the bore.

[0007] The provision of such a removable valve assembly with actuating means for communicating motive fluid to the bore to operate the valve assembly within the bore enables particularly efficient operation of the valve assembly.

[0008] The invention also provides a method of operating a fluid operated pump within a wellbore, the method utilizing a removable valve assembly within a longitudinal bore in a housing of the pump, wherein a first fluid path in the housing opening into the bore is provided for supply of pressurized fluid from the bore to an area of the pump below the housing, and a second fluid path in the housing opening into the bore is provided for an exhaust fluid from an area below the housing to the exterior of the housing, the method comprising lowering the valve assembly to a location in the wellbore proximate the bore in the housing; aligning the valve assembly with the bore; axially inserting the valve assembly into the bore such that ports in an outer valve surface communicate with the first and second fluid paths; and sealingly retaining the valve assembly in the bore during pumping of fluid by the pump; characterised in that the valve assembly is operated within the bore by motive fluid supplied to the bore by fluid actuating means.

[0009] In order that the invention may be more fully understood, embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a sectional view of a prior art gas operated pump assembly in a well;

Figure 2 is a sectional view of a housing for use in a first embodiment of the invention;

Figure 3 illustrates a removable valve assembly disposed on a coiled tubing string for insertion into the housing of Figure 2;

Figure 4 is a sectional view showing the removable valve assembly of Figure 3 disposed on coiled tubing and located in the bore of the housing of Figure 2;

Figure 5 illustrates a removable valve assembly for a gas operated pump in accordance with an further embodiment of the invention;

Figure 6 illustrates the valve assembly of Figure 5 inserted in a housing with an alignment tool being provided to install the valve assembly in the housing; and

Figure 7 illustrates a removable valve assembly and a housing in a still further embodiment of the invention with an electrical connection means therebe-

tween.

[0010] Figure 2 is a sectional view through a housing 200 of a gas operated pump in accordance with a preferred embodiment of the invention. The housing 200 includes two longitudinal bores 215, 225 as well as a number of internally formed motive fluid paths to operate a valve and to direct gas through the pump. More particularly the housing 200 includes an internally threaded portion 205 at its upper end for connection to a string of tubulars (not shown) and an externally threaded portion 210 at its lower end for connection to an accumulator chamber (not shown). The housing 200 has a first longitudinal bore 215 therethrough having an internally threaded portion 220 at its lower end for connection to a diptube (not shown). In use, the bore 215 serves as a conduit for production fluid pumped towards the surface of the well. The housing 200 also has a second longitudinal bore 225. An aperture 235 formed in a wall of the housing 200 provides communication between the second longitudinal bore 225 and the exterior of the housing 200. A third bore 230 provides communication between an injection port 250 in the wall of the second longitudinal bore 225 and the lower end of the housing 200 for injection of pressurized gas into the accumulation chamber (not shown).

[0011] The second longitudinal bore 225 further includes a first profile 240 and a second profile 245 formed within the bore 225 to receive a removable valve assembly (not shown) that is insertable in the upper end 255 of bore 225. In this arrangement, the profiles 240, 245 are continuous grooves and are formed to permit mating formations of the valve assembly to mate therewith as will be more fully described herebelow.

[0012] Figure 3 illustrates the removable valve assembly 300 disposed on the end of a coiled tubing string 325 for insertion into the housing 200 of Figure 2. The removable valve assembly 300 includes an inlet control valve 305, a vent control valve 310, a valve stem 315 and an actuator 320. The valve stem 315 is connected to both the inlet control valve 305 and the vent control valve 310. The actuator 320 moves the valve stem 315, alternatively opening and closing the inlet control valve 305 and the vent control valve 310. When the inlet control valve 305 is in the open position, gas flows down the coiled tubing string 325 into the assembly 300 and out through a gas outlet port 330. Alternatively, when the vent control valve 310 is in the open position, gas enters a vent inlet port 340 and exits through a vent outlet port 335. A first control conduit 345 and a second control conduit 350 are housed inside the coiled tubing string 325. The first control conduit 345 and the second control conduit 350 are typically hydraulic control lines and are used to actuate the valve assembly 300. Additionally, electrical power can be transmitted through the one or more of the control conduits 345, 350 to actuate the valve assembly 300. The valve assembly 300 may include data transmitting means to transmit data, such as pressure and temperature within the pump chamber, through the control conduits 345, 350 to the surface of the wellbore. In these instances, the valve assembly 300 or the housing 200 may include sensors. The transmitting means can include fiber optic cable.

[0013] A first seal 355, second seal 360, and third seal 365 are circumferentially mounted around an external surface of the valve assembly 300. The purpose of the seals is to isolate fluid paths between the valve assembly 300 and the housing 200 (Figure 2) when the valve assembly 300 is inserted therein. The assembly 300 further includes a first key 370 and a second key 375 to secure the valve assembly 300 axially within the housing 200. The first key 370 and the second key 375 are outwardly biased and are designed to mate with the profiles in the interior surface of the housing 200 (Figure 2).

[0014] Figure 4 is a sectional view of the valve assembly 300 disposed in the housing 200. In the arrangement of Figure 4, the valve assembly 300 is shown at the end of the coiled tubing string 325 that provides a source of pressurized gas to operate the pump. The accumulator chamber 415 for collecting formation fluid is secured to the housing 200 by the externally threaded portion 210 at the lower end of the housing 200. The tubing string 405 is secured to the housing 200 at the internally threaded portion 205. A diptube 410 is secured to the housing 200 by way of the internally threaded portion 220 of the first longitudinal bore 215. A vent line 420 is secured to the housing 200 at the aperture 235 to provide a passageway for gas venting from the accumulator chamber 415.

[0015] In operation, the removable valve assembly 300 is installed at an end of the coiled tubing string 325 and the string 325 is inserted in tubing string 405 at the top of the wellbore and the valve assembly 300 is lowered on the string 325 towards the housing 200. As the valve assembly 300 reaches the housing 200, a profile means and guide orient and align the valve assembly 300 with the second longitudinal bore 225 which is offset from the center of the housing 200. Profile means and guides are well known in the art and typically include some mechanical means for orienting a device in a wellbore. After insertion into the upper end 255 of the bore 225, the valve assembly 300 is urged downwards until the first key 370 and the second key 375 of the valve assembly 300 are secured in place in the first profile 240 and the second profile 245 of the housing 200. Mating angles on the keys and profiles permit the retention of the valve in the housing 200. The first seal 355 and the second seal 360 form a barrier on the top and bottom of the injection port 250 to prevent leakage of injected gas into the accumulator chamber 415. The second seal 360 and the third seal 365 provide a barrier on the top and bottom of the aperture 235 to prevent leakage of gas exiting the vent line 420.

[0016] After such installation of the valve assembly 300 the formation fluid supplied to the accumulator chamber 415 is pumped by operation of the inlet control valve 305

and the vent control valve 310 by means of the actuator 320 in the manner already described. 7

[0017] Figure 5 is a sectional view of an alternative valve assembly 500 and Figure 6 is a sectional view of the valve assembly 500 installed in a housing 600 in accordance with a further embodiment of the invention. The housing 600 of Figure 6 includes additional fluid paths formed therein but is otherwise similar to the housing 200 of Figure 2 and the valve assembly 500 of Figure 6 includes additional fluid paths formed therein but is otherwise similar to the valve assembly 300 of Figure 3, and like reference numerals are therefore used in Figure 6 to denote similar parts in these figures. Hydraulic conduits 630, 635 are formed in the housing 600 and serve to carry hydraulic power fluid from an upper end of the housing 600 to the longitudinal bore 645 formed in the housing 600. The conduits 630, 635 intersect the bore 645 at locations ensuring that they will communicate with the valve assembly 500 after it has been installed in the bore 645 and is retained therein with the retention means described with respect to Figure 4. Also formed in the housing 600 is an internal gas line 640 providing communication between the upper end of the housing 600 and the bore 645.

[0018] By providing hydraulic conduits 630, 635 and the gas line 640 internally within the housing 600, there is no need for separate hydraulic lines or a gas supply line to remain attached at an upper end of the valve assembly 500. As illustrated in Figure 6, the valve assembly 500 is installed in the bore 645 with a selective connector or gripping tool 607 that temporarily retains the valve assembly 500 by gripping a fish neck 580 formed at the upper end of the valve assembly 500. Gripping tools typically operate mechanically with inwardly movable fingers. A kickover tool can be utilized to align the valve assembly 500 with the offset bore 645. Kickover tools and gripping tools are well known in the art. Because no rigid conduits are needed between the surface of the well and the upper end of the valve assembly 500, the assembly 500 can be inserted and removed from the housing using wireline or slick line. After completion of the pumping operation and when it is required to withdraw the valve assembly 500 from the wellbore, the valve assembly 500 can simply be retrieved from the bore 645 in the housing 600 on the end of the wireline by exerting sufficient upward force on the wireline to overcome the sealing engagement of the valve assembly 500 within the bore 645.

[0019] Figure 7 is a sectional view of a removable valve assembly 700 in a longitudinal bore 720 of a pump housing 705 with an electrical connection therebetween, in accordance with a further embodiment of the invention. For clarity, the assembly 700 is illustrated only partially inserted into the housing 705. In the embodiment of Figure 7, the housing 705 is electrically wired with conductors 710, 715 that lead to a lower portion of the longitudinal bore 720. A contact seat 725 is located within the bore 720 and is constructed and arranged to receive an electrode 730 protruding from the lower end of the valve assembly 700. As the assembly 700 is inserted into the bore 720 and is axially located therein, the electrode 730 is seated in the contact seat 725 and an electrical connection between the housing 705 and the valve assembly 700 is made. Thereafter, the valve assembly 700 may be actuated electrically through the use of a solenoid switch 735 disposed within the valve assembly 700. As in the other embodiment of the invention, the housing includes flow paths formed therein that communicate with the valve assembly 700 and reduce the necessary bulk of the valve assembly 700. After completion of the pumping operation and when it is required to withdraw the valve assembly 700 from the wellbore, the valve assembly 700 can simply be retrieved from the bore 720 in the housing 705 on the end of the wireline.

Claims

1. A fluid operated pump for use in a wellbore, the pump comprising:

   a housing (200, 600, 705) with at least one longitudinal bore (225, 645, 720) therethrough;
   a first fluid path (250) formed in the housing (200, 600, 705) and opening into the bore (225, 645, 720) for communicating a pressurized fluid from the bore (225, 645, 720) to an area below the housing (200, 600, 705);
   a second fluid path (235) formed in the housing (200, 600, 705) and opening into the bore (225, 645, 720) for communicating an exhaust fluid from an area below the housing (200, 600, 705) to the exterior of the housing; and
   a removable valve assembly (300, 500, 700) axially insertable into the bore (225, 645, 720) of the housing (200, 600, 705) and having ports (330,335) that are constructed and arranged in an outer valve surface to communicate with the first and second fluid paths (250, 235) when the valve assembly (300, 500, 700) is inserted into the bore (225, 645, 720) and to selectively direct the pressurized fluid and the exhaust fluid;

   characterised in that fluid actuating means (345, 350, 630, 635) is providing for communicating motive fluid to the bore (225, 645, 720) in order to operate the valve assembly (300, 500, 700) within the bore (225, 645, 720).

2. The pump of claim 1, wherein the area below the housing (200, 600, 705) comprises an accumulator chamber (415) for receiving production fluid to be pumped by the action of the pressurized fluid.

3. The pump of claim 1 or 2, wherein the first fluid path (250) further includes a path extending from the bore

(225, 645, 720) to an area above the housing (200, 600, 705) for communicating the pressurized fluid from the area above the housing (200, 600, 705) to the bore (225, 645, 720).

4. The pump of any preceding claim, further including at least one seal member (360) between the valve assembly (300, 500, 700) and the bore (225, 645, 720) for isolating the first and second fluid paths (250, 235) from each other.

5. The pump of any preceding claim, further including a retention assembly (240, 245, 370, 375) between the valve assembly (300, 500, 700) and the bore (225, 645, 720) for retaining the valve assembly (300, 500, 700) in a predetermined axial position within the bore (225, 645, 720).

6. The pump of claim 5, wherein the retention assembly includes at least one outwardly biased formation (370, 375) extending radially from an outer surface of the valve assembly (300, 500, 700) and constructed and arranged to land in a profile (240, 245) formed on an inner surface of the bore (225, 645, 720), whereby, upon insertion in the bore (225, 645, 720), the valve assembly (300, 500, 700) seats in the bore (225, 645, 720) in the predetermined axial position.

7. The pump of claim 5 or 6, wherein the first and second fluid paths (250, 235) are interruptably completed when the valve assembly (300, 500, 700) is in the predetermined axial position within the bore (225, 645, 720).

8. The pump of any preceding claim, wherein the removable valve assembly (300) includes a coiled tubing string (325) extending from an upper end thereof, the string (325) serving as a conduit for the pressurized fluid.

9. The pump of any preceding claim, wherein the pump further includes an electrical connection (725, 730) between the valve assembly (700) and the bore (720) for actuation of the shift the valve assembly (700).

10. The pump of claim 9, wherein the electrical connection is made between a first mating member (730) on the valve assembly (700) and a second mating member (725) disposed in the bore (720), the mating members (725, 730) mating with one another as the valve assembly (700) is located in a predetermined axial position within the bore (720).

11. The pump of any preceding claim, wherein the valve assembly (500, 700) is connected to a wireline by a selective connector (607) for insertion into the bore (645, 720), the valve assembly (500, 700) being subsequently releasable from the wireline by disconnection of the selective connector (607).

12. The pump of claim 11, wherein the selective connector (607) is operable from the surface of the well.

13. The pump of any preceding claim, further including an alignment member constructed and arranged to align the valve assembly (300, 500, 700) with the bore (225, 645, 720) prior to insertion of the valve assembly (300, 500, 700)) into the bore (225, 645, 720).

14. A method of operating a fluid operated pump within a wellbore, the method utilizing a removable valve assembly (300, 500, 700) within a longitudinal bore (225, 645, 720) in a housing (200, 600, 705) of the pump, wherein a first fluid path (250) in the housing (200, 600, 705) opening into the bore (225, 645, 720) is provided for supply of pressurized fluid from the bore to an area of the pump below the housing, and a second fluid path (235) in the housing (200, 600, 705) opening into the bore (225, 645, 720) is provided for an exhaust fluid from an area below the housing to the exterior of the housing, the method comprising:

lowering the valve assembly to a location in the wellbore proximate the bore (225, 645, 720) in the housing (200, 600, 705);
aligning the valve assembly (300, 500, 700) with the bore (225, 645, 720);
axially inserting the valve assembly (300, 500, 700) into the bore (225, 645, 720) such that ports in an outer valve surface communicate with the first and second fluid paths (250, 235) ; and
sealingly retaining the valve assembly (300, 500, 700) in the bore (225, 645, 720) during pumping of fluid by the pump;

characterised in that the valve assembly (300, 500, 700) is operated within the bore (225, 645, 720) by motive fluid supplied to the bore (225, 645, 720) by fluid actuating means (345, 350, 630, 635).

15. The method of claim 14, wherein the pumping of fluid by the pump is effected by movement of the valve assembly (300, 500, 700) by motive fluid supplied to the bore (225, 645, 720).

16. The method of claim 15, wherein the motive fluid is a hydraulic fluid supplied by hydraulic control conduit means (345, 350, 630, 635).

17. The method of claim 14, 15 or 16, further including making an electrical connection (725, 730) between the valve assembly (700) and the bore (720).

18. The method of any one of claims 14 to 17, wherein the pumping of fluid by the pump is effected by the accumulation of production fluid to be pumped in an accumulator chamber (415) and the supply of pressurized fluid to the accumulator chamber (415) to force the production fluid along the wellbore.

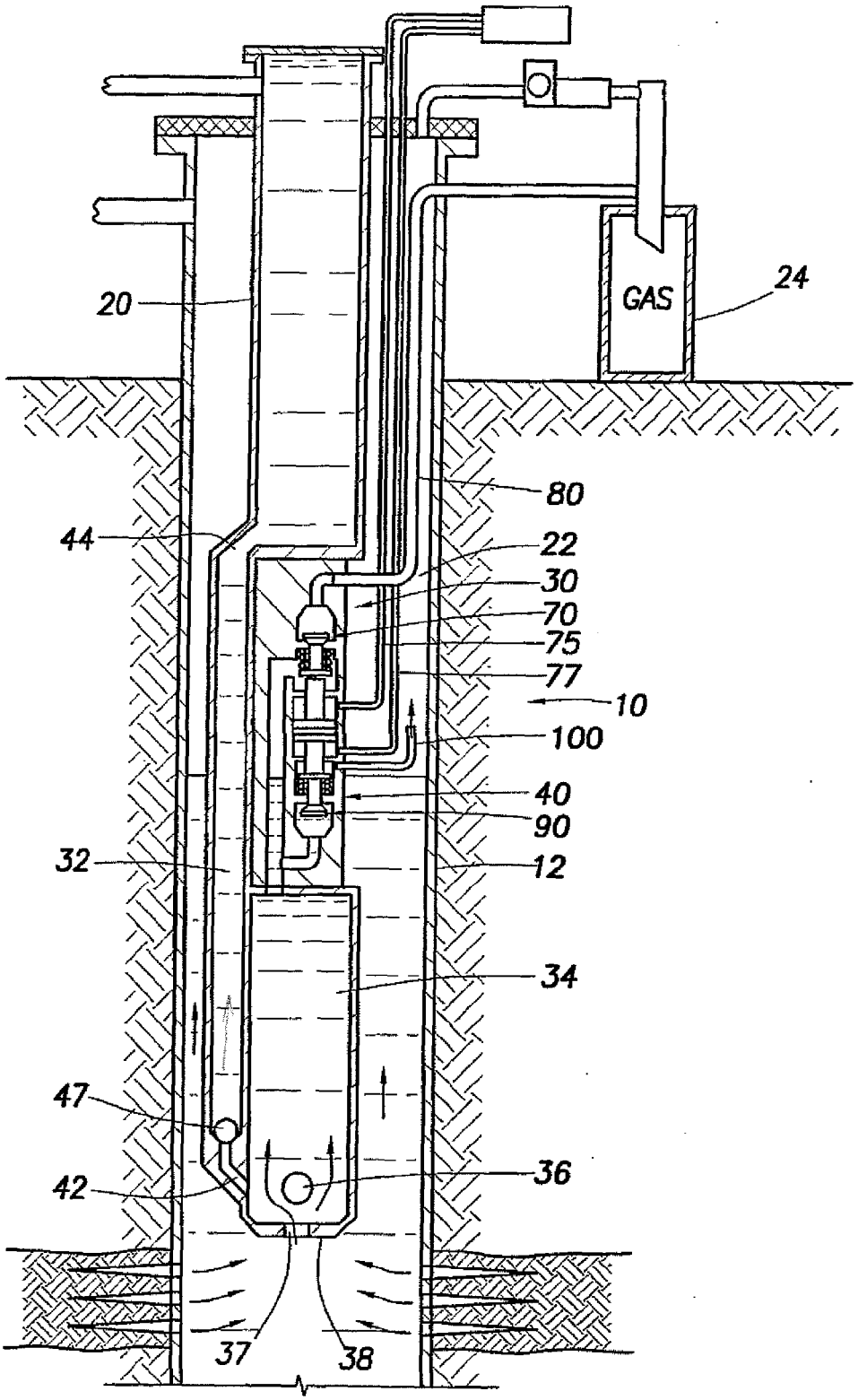

FIG. 1
(PRIOR ART)

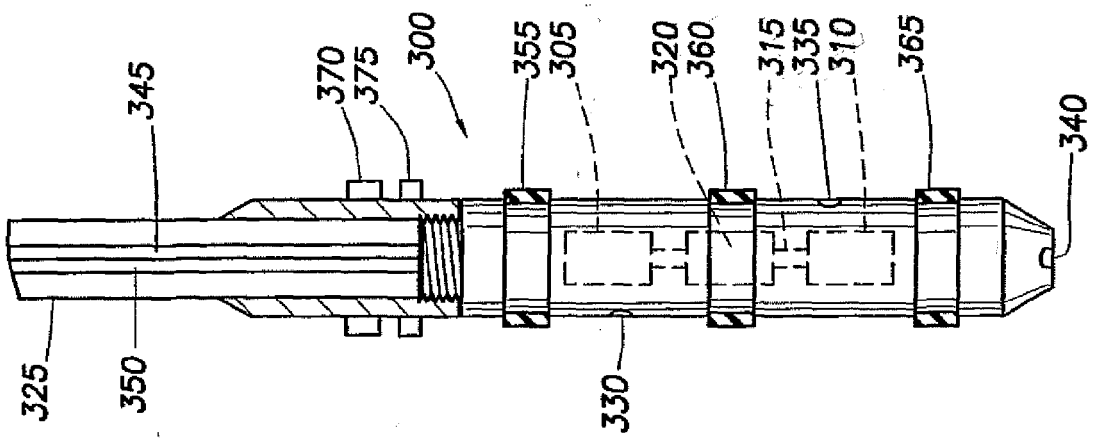
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FIG.3

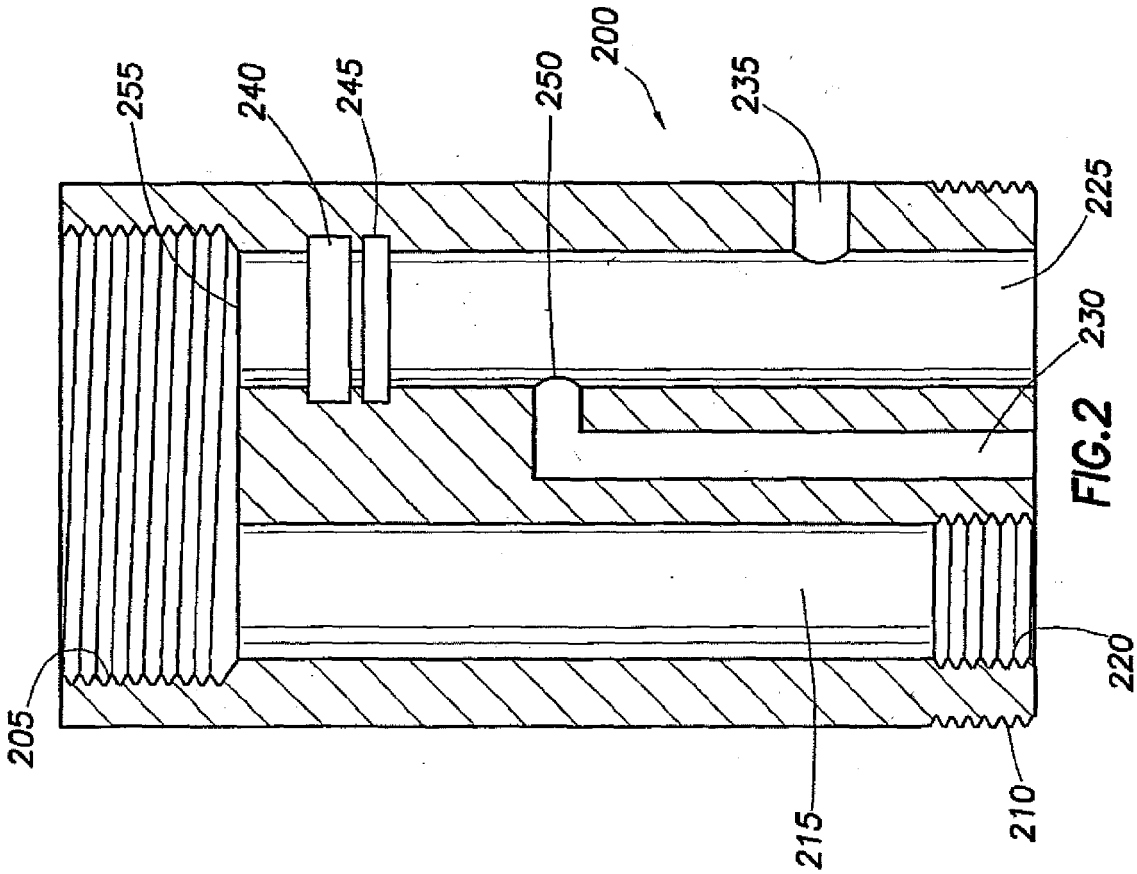
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FIG.2

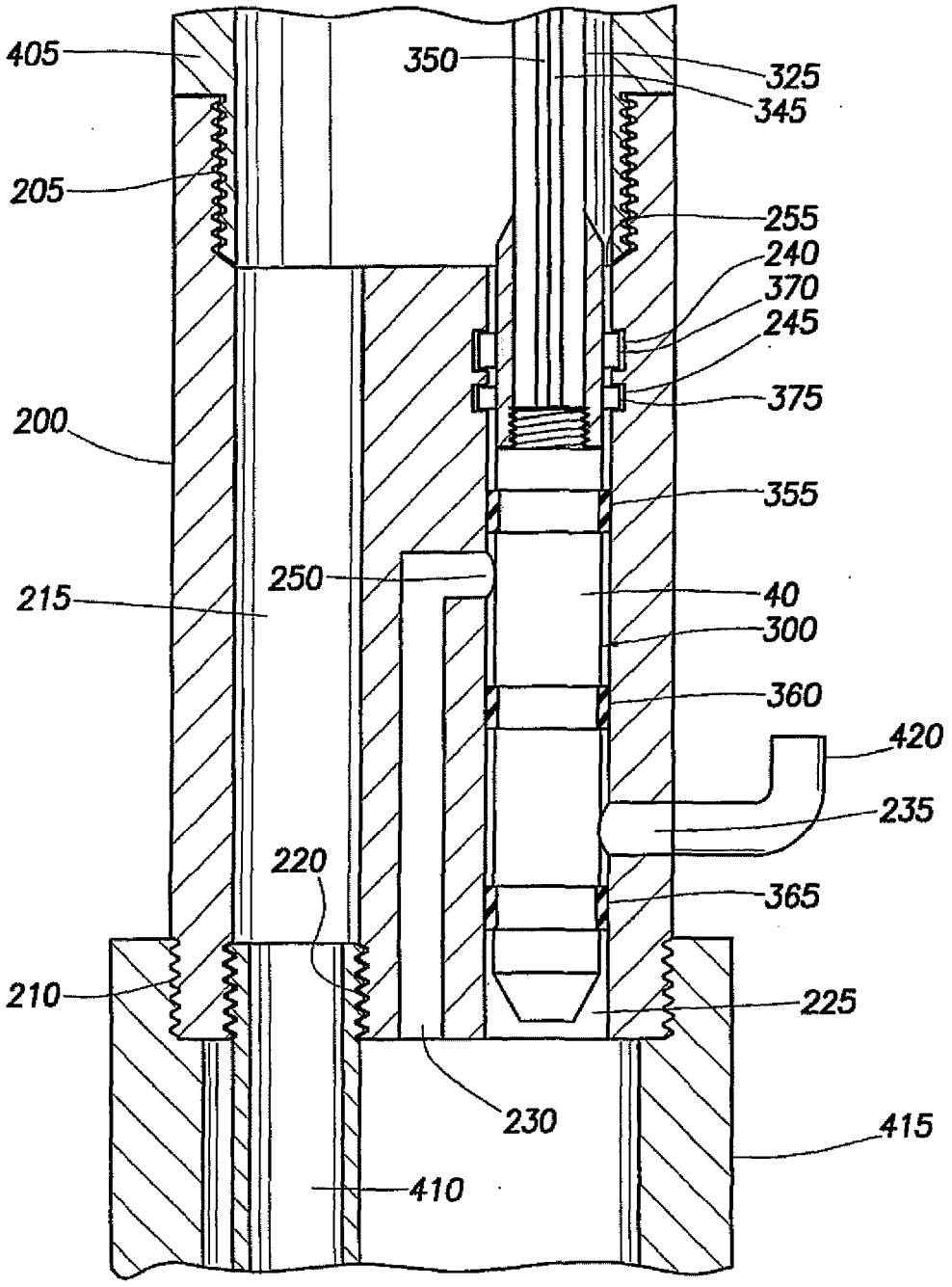
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FIG.4

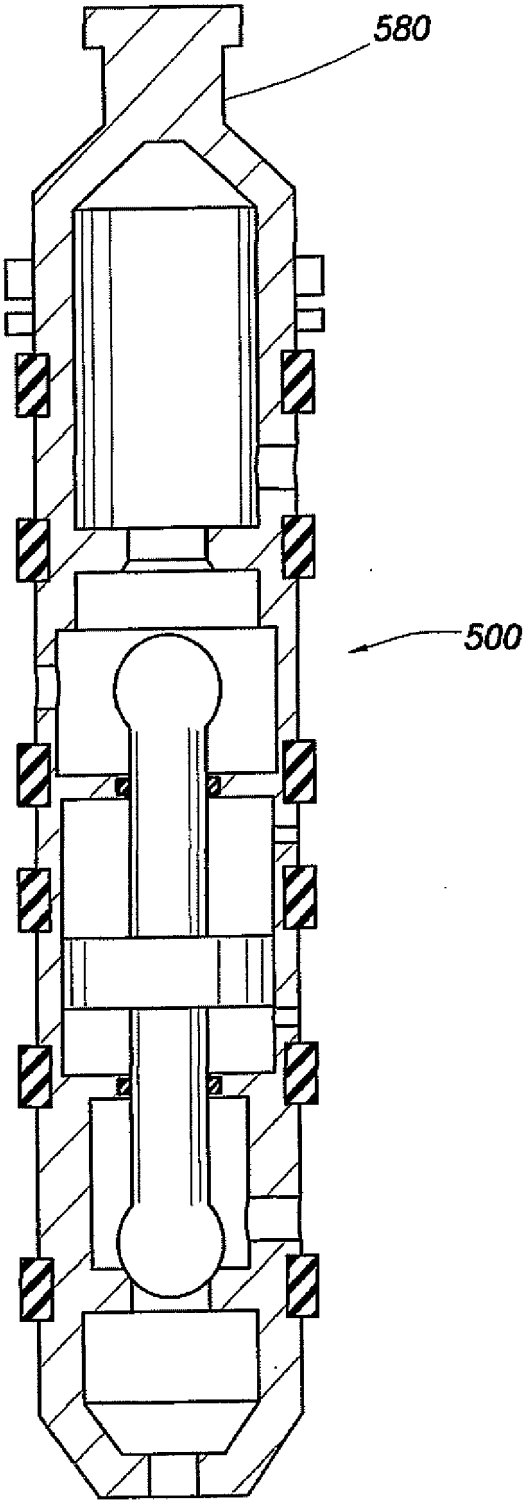

FIG.5

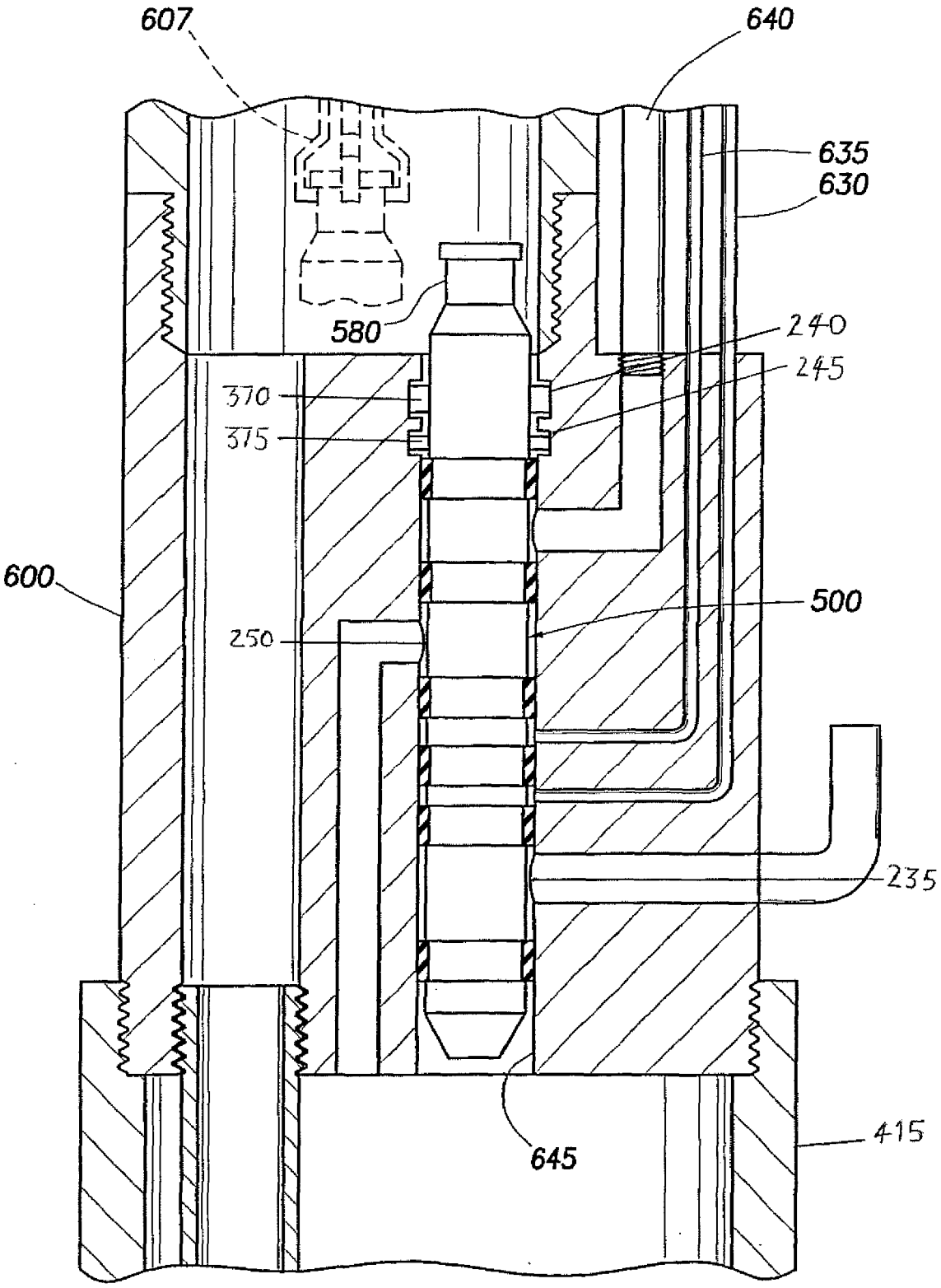

FIG.6

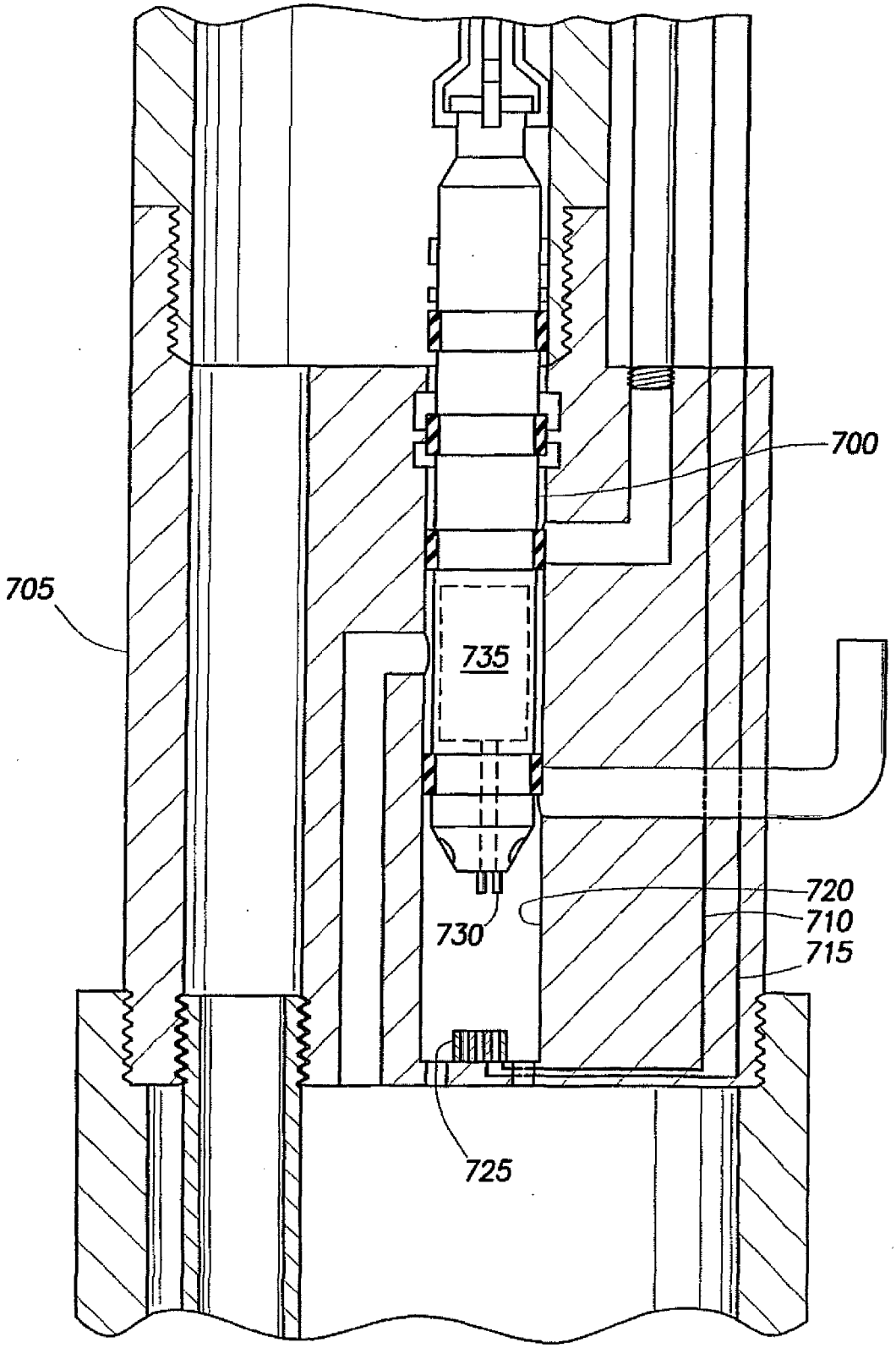

FIG. 7

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 11 0792

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	20 April 2006	van Berlo, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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L : document cited for other reasons

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 06 11 0792

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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